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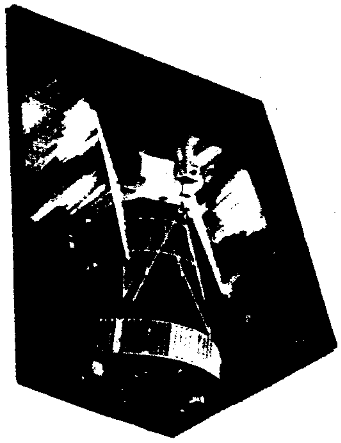

PROJECT: NIMBUS C

(To be launched no earlier than April 29, 1966)

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N·E W S NASA

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ROUND-THE-CLOCK

WEATHER PHOTOS

DUE FROM NIMBUS

A butterfly-shaped satellite scheduled for launch this month is the heart of a system designed to improve the speed and accuracy of weather forecasting services around the world.

For the first time, instantaneous, around-the-clock weather photographs from space will be available world-wide on simple, inexpensive ground equipment with the operation of the second Nimbus satellite.

The 912-pound Nimbus-C will be the nation's largest weather-watching satellite and will carry more instrumentation than any of its predecessors.

If orbited as planned, it will be designated Nimbus II. Launch is scheduled no earlier than April 29 from the Western Test Range aboard a Thrust-Augmented Thor-Agena B rocket.

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Nimbus I, launched successfully by the National Aeronautics and Space Administration in 1964, could send its daytime pictures to simple Automatic Picture Transmission (APT) ground stations, but lacked the capability of transmitting nighttime infrared photos via APT.

The second NASA Nimbus can cover 150 APT stations around the clock, including 44 stations in 26 foreign countries. Previously, the after-dark photos could be received only at a few stations with expensive, highly complex equipment.

If proper orbit is obtained, APT stations in the Northern Hemisphere will receive the orbiting weather eye's pictures three times a day and three times each night.

Nimbus is a continuing NASA program in basic meteorological research to develop new and more advanced weather satellite systems and weather sensors.

The 10-foot-tall Nimbus can send day and night weather photos direct to several commercially-owned television stations which are equipped with APT.

APT works on the electronic slow-scan principle similar to that used to transmit photographs by radio. As the satellite passes over a station, its picture is sent to the APT station below where the station operator can watch the picture form on his facsimile machine.

One of the most significant scientific tasks assigned to Nimbus C is to measure, for the first time on a global basis, the heat balance budget (albedo) of the entire 200-million-square-mile-area of the Earth every day--how much of the Sun's radiation the world absorbs daily and how much is reflected back into the atmosphere.

Physicists at NASA's Goddard Space Flight Center, Greenbelt, Md., hope this heat balance study may unlock some of the mystery of weather storm development and dissipation. The sensor for this experiment, flying for the first time on Nimbus, is called Medium Resolution Infrared Radiometer.

To carry out the assignment of mapping the world's weather phenomena for research and development purposes, Nimbus C is scheduled to go into a circular, near polar orbit, 690 statute miles high, and inclined 80 degrees to the equator. The orbital period will be 107 minutes.

In addition to its research and development mission, data collected by Nimbus C will be forwarded to the Commerce Department's Environmental Science Services Administration for operational weather forecasting purposes.

Nimbus will carry four weather-measuring sensors, the largest number flown on a meteorological satellite. They include three advanced vidicon cameras and one APT camera for taking daytime pictures; a High Resolution Infrared Radiometer (HRIR) for taking nighttime pictures; and a Medium Resolution Infrared Radiometer for measuring the Earth's heat balance. APT equipment can receive HRIR transmissions.

Project officials estimate that Nimbus C, which is always pointing directly at the world below, will take about 3,000 pictures daily.

A significant experiment in the upcoming Nimbus mission is a communications subsystem in the spacecraft designed to provide APT stations with daily orbital information, a requirement necessary to receive pictures.

Heretofore, APT stations received via teletype daily orbital information from Goddard which told each station precisely when Nimbus would be in the area and where the antenna should point for picture receipt.

APT photos from Nimbus C will have a code written on the left side of each picture with daily orbital information. The APT operator, by using a manual provided by NASA, can thus determine satellite arrival times and antenna-pointing angles for each orbit. If this experiment is successful, weekly teletype messages would no longer be needed.

The Nimbus project is managed by the Office of Space Science and Applications of the National Aeronautics and Space Administration. Goddard Space Flight Center is responsible for project management. Lewis Research Center, Cleveland, is project manager for the Thor Agena B.

Nimbus C will be launched by the U.S. Air Force 6595th Aerospace Test Wing under technical supervision of NASA's Kennedy Space Center, Fla.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS)

NIMBUS BACKGROUND INFORMATION

Photos from Nimbus C will not be transmitted until it has been determined that all spacecraft subsystems are working properly. The operational plan is to turn on each subsystem in a series of steps, and then command the satellite to start taking pictures.

All stored pictures, and radiation data of the earth's heat balance, will be sent from Nimbus to tracking stations at Fairbanks, Alaska, or Rosman, N. C., for immediate microwave transmission to Goddard for "real time" processing and analysis.

The nominal turn on time for sensor experiments, which could vary about one hour due to the one hour launch window, is as follows:

The nighttime-picture-taking-system (High Resolution Infrared Radiometer) and the Medium Resolution Infrared Radiometer will send pictures and heat balance data respectively, to Goddard on the 4th orbit, between 11:00 a.m. and noon EDT on launch day.

During the 5th orbit, between 1:00 and 2:00 p.m., the first daytime pictures will be sent live from Nimbus to Goddard. This strip of approximately three pictures will show the Caribbean, East Coast of the United States, and the southern portion of Canada.

Also on the fifth orbit, engineers will turn on the HRIR for a daytime picture sequence to determine if the direct readout system for receiving infrared pictures on APT equipment is working.

The advanced vidicon cameras will send stored pictures of the Mid-west on the sixth orbit, between 3:00 and 4:00 p.m.

Goddard will receive the first direct readout of nighttime infrared pictures on APT equipment on the 13th orbit, about 2:00 to 3:00 a.m. on the second day Nimbus is in orbit.

Nimbus C will follow the smaller Nimbus I which was launched Aug. 28, 1964, and took some 27,000 remarkably sharp pictures. The satellite stopped operating Sept. 23, 1964, because of a power failure (See page 10).

As a result of the high resolution pictures returned from Nimbus I, scientists have found that in addition to meteorological research, the data from the Nimbus orbiting platform can be used for research in geology, topographic mapping, forestry, ice pack reconnaissance, hydrology and oceanography.

Map makers are extremely interested in Nimbus pictures. The U.S. Geological Survey, after studying more than 300 pictures taken by Nimbus I over the Antarctic, found that relief maps of the Antarctic were in slight error.

The results are that Mount Siple, a 10,000-foot-high Antarctic-mountain will be repositioned on future maps 45 miles to the West, and current maps of the Kohler Range area, also at the Antarctic, show only one group of mountains, not two as Nimbus I has shown.

Also, pictures of the Earth taken by Nimbus C can be applied to the study of pictures of other planetary surfaces, particularly Mars, according to geologists at Goddard.

Sensors scheduled for future Nimbus flights will measure the atmosphere's vertical structure, monitor the world's wind patterns by tracking balloons and will collect meteorological data from unmanned weather stations, on land as well as buoys at sea.

This world-wide collection of weather information is part of a long range program of numerical forecasting, and it is hoped that this system will lead to accurate weather predictions two weeks, and possibly more, in advance.

The research and development Nimbus is a follow-on to NASA's highly successful TIROS (Television Infrared Observation Satellite) program which scored 10 successes in 10 attempts.

The results of TIROS led to the world's first operational satellite system (called TIROS Operational System) of the Department of Commerce.

The Nimbus program is a combined government/industry effort. Twenty-five (25) major subsystem contractors are responsible for various components in the spacecraft, launch vehicle, or ground receiving equipment. In addition there are more than 1,000 subcontractors and vendors working on the program.

Nimbus I Power Failure

Nimbus I lost all power and began tumbling due to a mechanical malfunction in the satellite's solar array drive subsystem. Thus, the paddles locked and no longer turned toward the Sun so that the cells could no longer be nourished by it. This resulted in complete loss of electrical power.

An extensive ground test program has shown that the paddles locked due to overheating in the drive system. As the temperature kept rising, the grease degraded, the gears in the system chipped, and the solar paddles locked.

Several modifications have been made in the Nimbus C solar array drive to correct the problem.

A larger drive motor, with six times greater torque, will be used and the rotor of the new motor has been coated black to improve the thermal radiation in the solar array drive area.

Also, the motor case was heat sunk to the spacecraft frame with a piece of metal (heat strap) extending from the motor housing to the control subsystem so heat will be better distributed throughout the satellite.

Infrared photometer measurements have been made on new solar array drive subsystems which have demonstrated a significant reduction in temperature.

Life tests on several redesigned solar array drive units have been conducted under thermal vacuum conditions and the new units operated satisfactorily after six months of exhaustive testing.

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Nimbus C Fact Sheet

Spacecraft.....................Butterfly shaped, 10-feet-tall, 11 feet wide, with a five-foot diameter sensury ring weighing 912 pounds;

Mission Objectives............Provide data from the digital Medium Resolution Infrared Radiometer system for study of the Earth's heat balance;

Provide nighttime (infrared) and daytime global pictures for research purposes;

Demonstrate day-night direct local readout of Automatic Picture Transmission and High Resolution Infrared Radiometer using the APT transmitter;

Provide seasonal and hemispheric coverage of weather systems for research and for real time application by the weather data users; and

Demonstrate long life performance (six months) of the basic Nimbus spacecraft.

Launch Information:

Vehicle..................Thrust Augmented Thor (TAT) Agena B.

Launch Pad...............Space Complex 1-1, Western Test (Vandenberg AFB), Calif.

Launch Azimuch...........194 degrees true.

Date.....................No earlier than April 29, 1966.

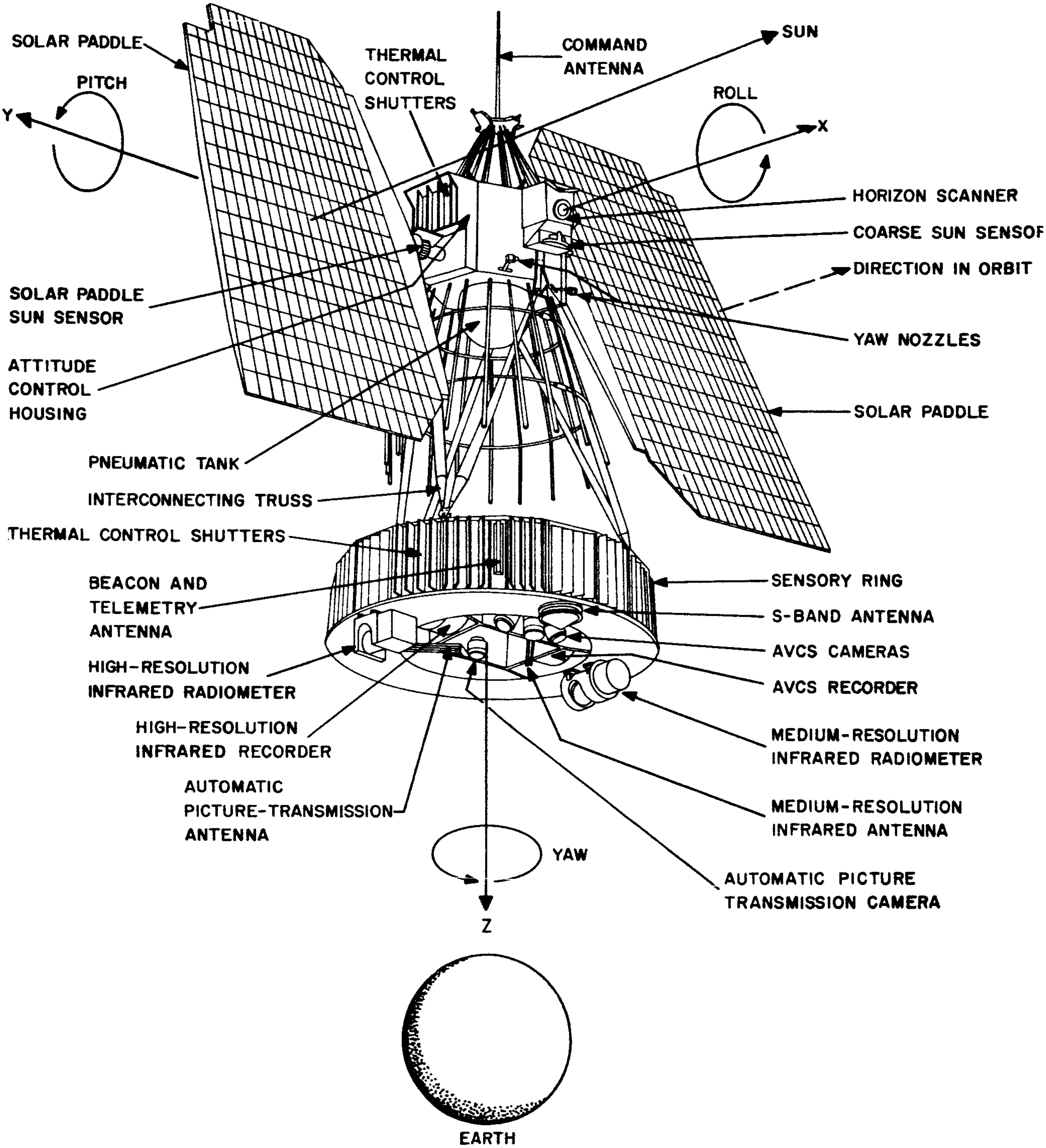
Orbital Elements

Orbit..........................	Circular, 690 statute miles high (1,100 kilometers).
Period.........................	107 minutes.
Inclination....................	Near polar and sun synchronous, 80 degrees retrograde to the equator.
Velocity.......................	16,564 miles per hour.

Meteorological Sensors:

Advanced Vidicon Cameras....	Three daytime television cameras in the advanced vidicon camera subsystem will take about 1,300 pictures, of the entire earth every day with a resolution of about ½-mile at picture center.
Automatic Picture Transmission Camera............	Another daytime camera sends "live" pictures to simple ground stations. The APT camera has a resolution of about 2-miles at picture center.
High Resolution Infrared Radiometer................	The High Resolution Infrared Radiometer takes pictures in total darkness with a resolution of about 5-miles at picture center. For the first time in weather satellite research, APT stations can receive nighttime pictures.
Medium Resolution Infrared Radiometer............	Will measure the earth's heat balance budget which could affect weather storm development and dissipation.
Power Supply......................	10,500 negative on positive (N on P) solar cells mounted on two, eight-by-three feet rotating solar paddles. The cells convert solar energy to electrical power to keep the satellite's eight batteries fully charged.

Orbital Tracking................	Sixteen stations of the world-wide Space Tracking and Data Acquisition Network (STADAN) and the Tananarive, Hawaiian and Pt. Arguello Manned Flight Network Stations, operated by the NASA/Goddard Space Flight Center.
Data Acquisition Facilities.....................	Fairbanks, Alaska Rosman, N.C.
APT Ground Stations.............	Approximately 150 stations, including 44 stations in 26 foreign countries.
Spacecraft Management...........	Office of Space Science and Applications, NASA Headquarters, and NASA's Goddard Space Flight Center.
Launch Vehicle Management.....................	NASA/Lewis Research Center
Launch Operations................	U.S. Air Force 6595th Aerospace Test Wing under the technical supervision of the NASA/Kennedy Space Center Unmanned Launch Operations.



Nimbus C Flight Spacecraft

Nimbus Spacecraft Structure

The Nimbus spacecraft stands 10 feet tall and weighs 912 pounds. The spacecraft structure was manufactured by the General Electric Co.

Nimbus' configuration consists of three major elements: The eight-foot-tall by three-foot-wide-solar-paddles which provide the spacecraft's electrical power supply; the upper most structure of the spacecraft which is a hexagonal package containing the complete attitude stablilization and control subsystem for pointing the satellite directly at the earth; and the lower section, a five-foot-diameter-sensory ring which contains the satellite's batteries, transmitters and other associated electronic equipment.

The ring, which houses all of the weather measuring experiments and resembles a large wheel, is in the form of a hollow circular section composed of 18-rectangular module pockets and V-shaped separators.

A truss structure connects the upper control subsystem to the lower wheel-like-sensory-ring at three points. This truss structure provides the critical alignment required between the other two sections.

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Nimbus Weight and Power Requirements

Spacecraft	Weight	Power Requirements
Structure	118	
Thermal	50	5.2 watts
Harness	75	
Telemetry	45	6.2 watts
Command	33	9.3 watts
Controls	181	76 watts
Solar Power	138	39 watts (heat loss)
Paddles	75	
High Data Rate Storage	55	
SUB TOTAL	770 lbs.	

Experiments	Weight	Power Requirements
APT Camera	30	40 watts
Three Advanced Vidicon Cameras	63	27 watts
HRIR	12	11.3 watts
MRIR	36	10 watts
Solar Cell Experiment	1	
SUB TOTAL	142 lbs.	

TOTAL NIMBUS C SPACECRAFT WEIGHT: 912 pounds

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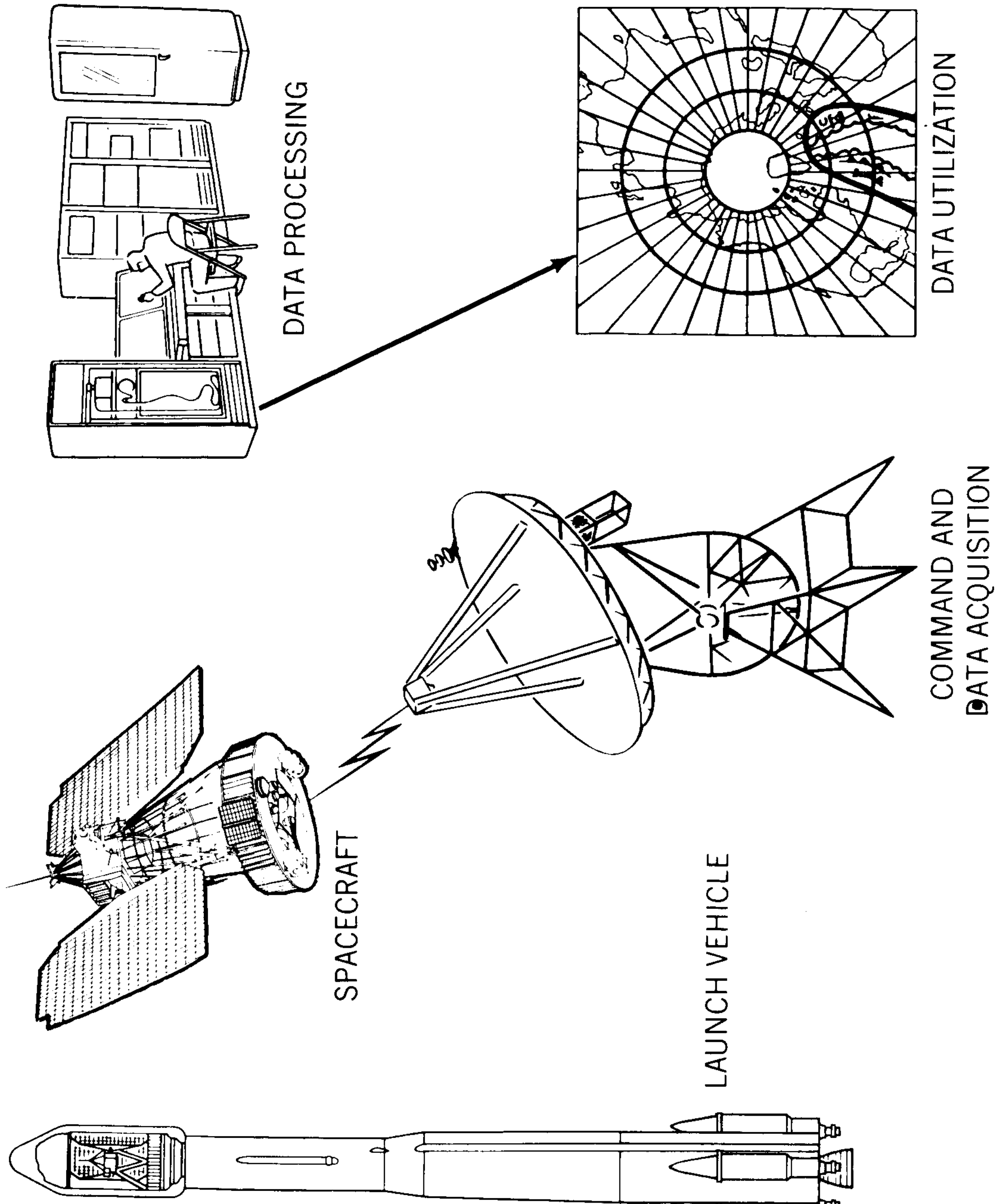

THE NIMBUS SYSTEM

Attitude Control Subsystem

One of the most critical subsystems in Nimbus C is the attitude control section (uppermost section of the spacecraft) which must always keep the weather observer pointed directly at Earth.

This control subsystem is designed to keep the spacecraft Earth-oriented and stabilized in all three axes (pitch, yaw and roll), so Nimbus' sensitive camera eyes can always look at the world below.

In addition to keeping the satellite pointed at Earth, the control subsystem plays an important role in keeping the batteries charged.

The two large solar paddles on Nimbus are mounted on shafts which extend from the side of the control subsystem. A small motor, which receives instructions from the control subsystem, slowly turns the paddles toward the Sun so the tiny cells on the paddles can convert solar energy into electrical power.

Although Nimbus is unmanned, it has a human-like-pilot in the way of a computer which is small in size (it only weighs 19 pounds), but has a king size job. Here's how the control subsystem works:

Two infrared horizon scanners seek out the Earth's curvature, plus its heat, to determine if Nimbus is in the right attitude in relation to the world almost 700 miles below.

This information is passed along to a mechanical pilot (computer). Just as a pilot pulls back on the stick if his airplane is in a dive, the computer determines if Nimbus is rolling or swinging away from the Earth slightly.

The computer has two alternatives. If the correction is a small one, it tells three flywheels, one each for pitch, yaw and roll, to spin up. This corrects the satellite's attitude.

If a major correction is required, the robot pilot commands the flywheels to stop and freon gas spurts from tiny, silvery nozzles on the top and on the sides of the control subsystem.

The freon actuating gas is contained in a titanium storage tank attached by strap fasteners in a well at the bottom of the control subsystem. The initial gas charge is 6.5 pounds of freon compressed to 1,250 pounds per square inch at 68 degrees Fahrenheit.

Power Supply

During periods of full solar illumination, the initial solar array power output is about 470 watts which results in approximately 165 watts of continuous regulated power for spacecraft and experiment operation. This includes the daytime and nighttime portions of the orbit.

Nimbus C's power supply, which delivers minus 24.5 volts regulated to within plus or minus two percent, consists of an array of 10,500 negative on positive (N on P) solar cells mounted on two, 3-by-8-foot rotating paddles, eight nickel cadmium storage batteries and regulating and protective devices.

Power is obtained by the tiny cells soaking up energy from the Sun which is converted into electrical power to keep the eight batteries fully charged.

The solar cells are mounted on only one side of the paddles, for structural integrity and thermal conductivity, so the paddles must rotate slowly and track the Sun.

A highly sensitive Sun sensor mounted on the control subsystem tracks the Sun and a small motor turns the paddles one complete revolution (360 degrees) per orbit.

To help lower the operating temperature of the cells, a red-blue filter rejects that portion of the spectrum in which the cells are insensitive.

The expected, average paddle-operating temperature is approximately plus 100 degrees Fahrenheit with extremes ranging from a minus 176 degrees to plus 140 degrees.

The Nimbus storage batteries are packaged into eight parallel-connected modules, each consisting of 23 series-connected nickel cadmium cells. Each cell has a 3.2 ampere-hour capacity with a minimum terminal voltage, at discharge, of 1.15 volts.

Clock and Command Subsystem

The highest quality pictures ever taken, from the best satellite ever built, which has been placed into an almost perfect orbit would be largely useless without a timing system.

Meteorologists must know precisely when the picture was taken, and precisely where, so the photos can be useful for gridding and weather analysis. The clock subsystem assigns a specific time to each picture sequence and a computer on the ground grids (latitude and longtitude lines) each picture.

Nimbus' clock and command subsystem can handle as many as 128 commands at a time.

Coded commands from the ground, after they pass through the satellite's command receivers, are sent to the command clock.

This clock acts much like an alarm clock in that it tells the daytime cameras when to turn on and off and gives the same instructions to the infrared sensors. The clock also determines when Nimbus should start sending spacecraft performance data, and pictures, to ground stations.

The clock uses a crystal-stabilized oscillator, which provides absolute time determination, to relate the orbital location of the spacecraft to its geographical position. The 800-kilocycle aged-crystal which provides accurate timing reference is sealed in glass and maintained at a constant temperature by a heating coil.

Telemetry Subsystem

During the day, Nimbus data in terms of words would fill seven 30-volume sets of encyclopedias.

To handle such extremely large amounts of data, two telemetry subsystems are used.

PCM Housekeeping Subsystem

Nimbus uses a pulse code modulation (PCM) telemetry system for transmitting satellite status (commonly called housekeeping information) reports to the ground.

The more than 410,000 words of housekeeping information collected each orbit reveal the status of the satellite's power supply, temperature, attitude in space, camera subsystems and status of every other subsystem in the spacecraft.

This interrogation on Nimbus' electronic health is as thorough as the physical examinations astronauts undergo before a launching, and it's done on every orbit.

All of the housekeeping dataare handled in one of three ways. One mode provides stored data, on a tape recorder by means of an endless-loop tape recorder while another sends real, or "live", data on command. A third mode provides a very low rate emergency data readout.

Wide Band Sensory Telemetry

Meteorological data from the satellite's daytime and nighttime cameras pour into the Goddard ground station at a rate of 465 million bits per orbit. Each bit represents a separate piece of information.

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The S-band transmitter, attached to the sensory ring or lower-most structure of the spacecraft, sends both advanced vidicon camera and high resolution infrared radiometer pictures over the 1707.5 megacycle frequency. The S-band radiates a circulatory polarized wave with a 110-degree beam width.

Thermal Control

A combination of active and passive thermal-control techniques provides average temperature throughout the spacecraft which is favorable for the electronic equipment. With the exception of the solar paddles, an average temperature of about 75 degrees Fahrenheit plus or minus 5 degrees is maintained.

The Nimbus C configuration provides thermal separation and permits independent thermal control for each major segment of the spacecraft--the two solar paddles, sensory ring, and attitude control section.

Heat and cold are controlled in the sensory ring and control section by pneumatically activated shutters on the outside of the two sections. These shutters open and close automatically.

Nimbus C Meteorological Experiments

The research and development Nimbus C will carry more weather measuring instruments (four), than any of the previous meteorological satellites.

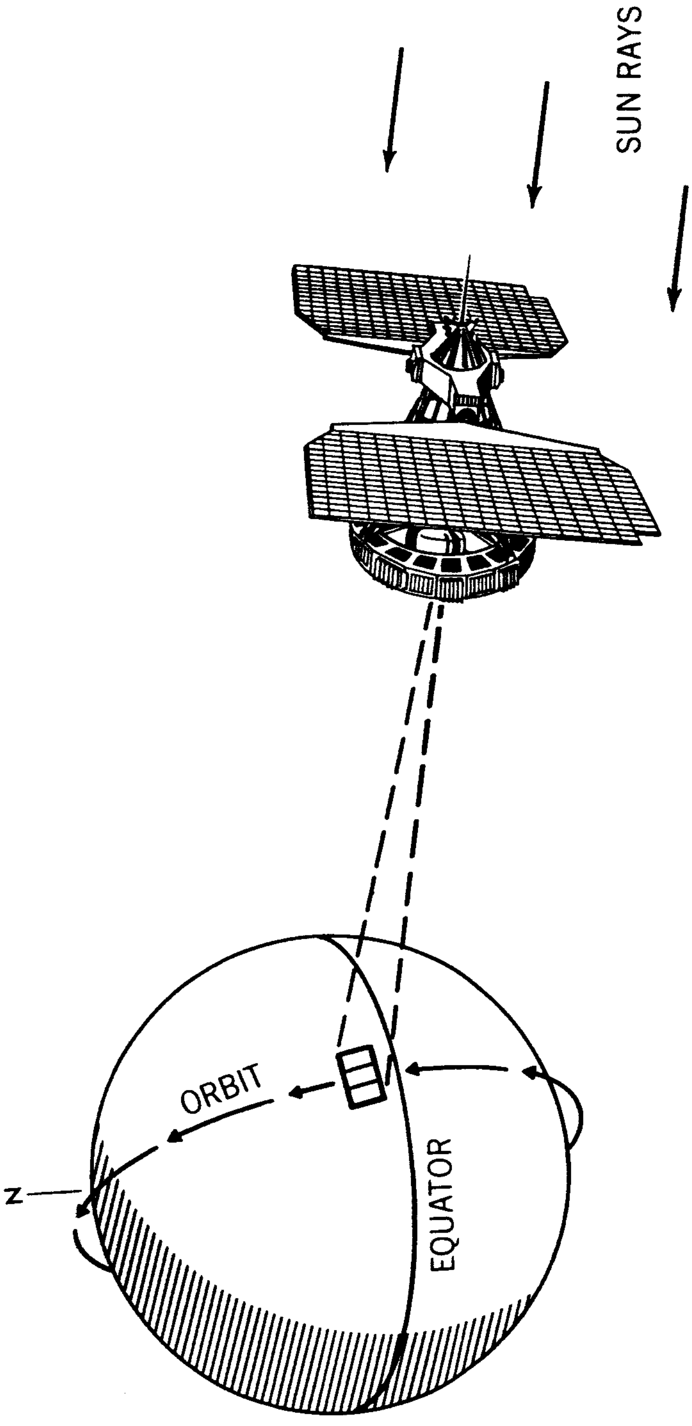
These four sensors, mounted on the sensory ring, or lowermost structure of the satellite, include three daytime cameras in the Advanced Vidicon Camera Subsystem, one Automatic Picture Transmission camera, one High Resolution Infrared Radiometer (nighttime sensor), and one Medium Resolution Infrared Radiometer (daytime and nighttime sensor).

Advanced Vidicon Camera Subsystem

Pictures from Nimbus C's Advanced Vidicon Camera Subsystem (AVCS) have the highest resolution of any television camera ever flown on weather satellites.

The 63-pound AVCS on Nimbus C is identical to the AVCS which flew on Nimbus I, on the Ranger spacecraft, and is scheduled for operation on future ESSA weather satellites.

Pictures taken by the AVCS have a resolution, at picture center, of about ½-mile.



ADVANCED VIDICON CAMERA SUBSYSTEM (AVCS) COVERAGE

Two full orbits of pictures (192) can be sent from Nimbus to Data Acquisition Facilities (DAF) at Fairbanks, Alaska, or Rosman, North Carolina, in only four minutes.

The S-band transmitter transmits video signals--these signals are later reconstructed into glossy pictures--to a DAF using the 1707.5 megacycle frequency.

Automatic Picture Transmission Camera

The entire world got its first look at direct readout pictures from a weather satellite on Dec. 21, 1963, the day TIROS VIII was launched from Cape Kennedy, carrying the first Automatic Picture Transmission camera.

Meteorologists are looking forward to the Nimbus C mission because it will double the weather coverage from a satellite and mark the first time that APT stations can receive live infrared pictures from an orbiting platform.

Three cameras, deployed in a fan-like array, make up the AVCS. This arrangement produces a three-segment composite picture which can be stripped together into a mosaic photograph which looks just like the maps in a geography book.

Each of the three cameras in the AVCS covers a 37-degree field of view with the center camera pointing straight down (local vertical or at a 90 degree angle to the Earth).

The optical axes of the other two cameras in the AVCS are rotated 35 degrees to the right and left of local vertical.

This angular arrangement produces a composite picture which provides the lateral field of view (2-degree overlap at the equator) necessary to cover the 27-degree rotation of the Earth between spacecraft passes.

Each three-strip picture from the AVCS will cover an area of approximately 800,000 square miles.

A timer in the spacecraft commands the three-advanced vidicon cameras to take a three-picture set every 91 seconds (during the daylight portion of each orbit), or 96 pictures per orbit, or more than 1,300 pictures daily.

To allow for spacecraft motion, the cameras are limited to a 40-millisecond exposure time. Three synchronized electro-magnetic shutters, and appropriate timing circuitry, control the shutter speed.

The three cameras employ a 17mm f/4 lens with a servo-controlled iris for exposure adjustment. A potentiometer attached to the solar array drive unit controls the lens opening from f/16 when the spacecraft is over the equator to f/4 when Nimbus C is near the poles.

As the Nimbus C research-station-in-space approaches the Earth's shadow, at a Sun angle of 85 degrees, the advanced vidicon cameras shut off (the nighttime infrared sensors turn on) and do not take pictures again until the satellite approaches the proper Sun angle some 50 minutes later.

For storing pictures for later playback, the three-AVCS cameras have a tape recorder, built by the Radio Corporation of America, with 1,200 feet of tape to record two complete orbits, or 192 pictures.

A switch stops the recorder when the tape is filled to capacity.

APT station managers in the northern hemisphere, if they have made minor equipment changes (see page 49) can expect to receive six of the 14 daily orbits.

The addition of infrared pictures at APT ground stations not only doubles the meteorological coverage, but provides weather men with cloud heights as well as cloud temperatures. Daytime photographs from a weather satellite can do neither.

The APT subsystem, unlike the advanced vidicon cameras, does not store pictures for later transmission. It sends weather pictures on the slow scan principle similar to that used to transmit radio photographs.

A timer in the APT subsystem programs the equipment for continuous cycles of "prepare-and-expose" during the first eight seconds of each 208-second picture cycle.

Approximately 200 seconds are required to read out each photograph at a ground station at a scan rate of four lines per second.

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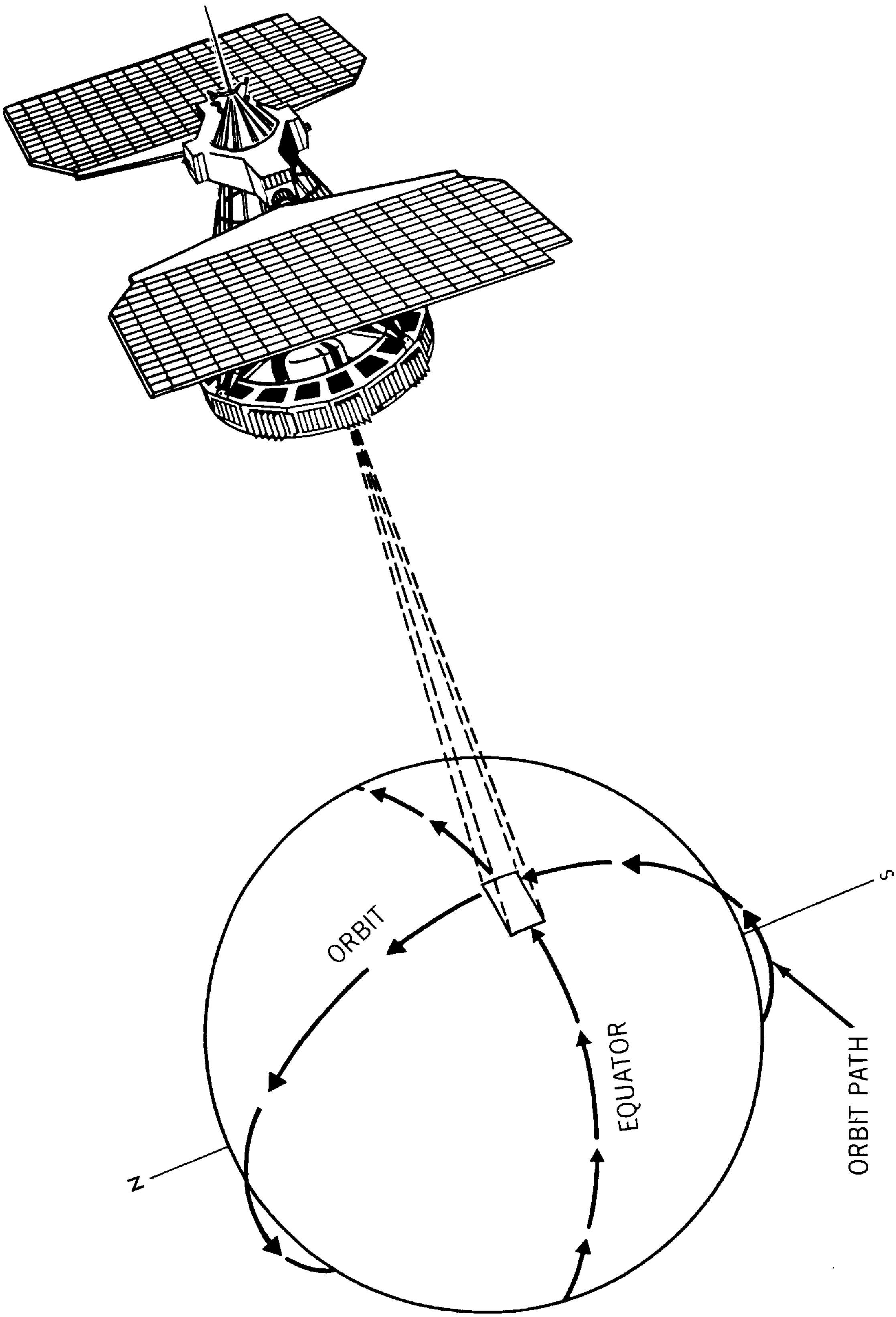


AUTOMATIC PICTURE-TRANSMISSION (APT) COVERAGE

Four major elements make up the APT subsystem in the spacecraft: the sensory housing which contains the camera; vidicon and vidicon electronics; a video electronic module consisting of a video detector, and timing and switching circuitry; power converters; and an FM transmitter using the 136.95 megacycle frequency.

The 31-pound APT camera in Nimbus C will run continuously during each daylight orbit (approximately 50 minutes each orbit).

The 108-degree lens used in the APT is a 5.7 mm f/1.8 Tegea kinoptic wide angle lens. A 40-millisecond exposure of the electromagnetic shutter produces an 800-scan-line picture on the photo-sensitive surface of a special one-inch diameter vidicon.

At an orbital altitude of 690 statute miles, the APT should have a picture resolution of two miles at picture center and each picture will cover an area in excess of two million miles.

High Resolution Infrared Radiometer

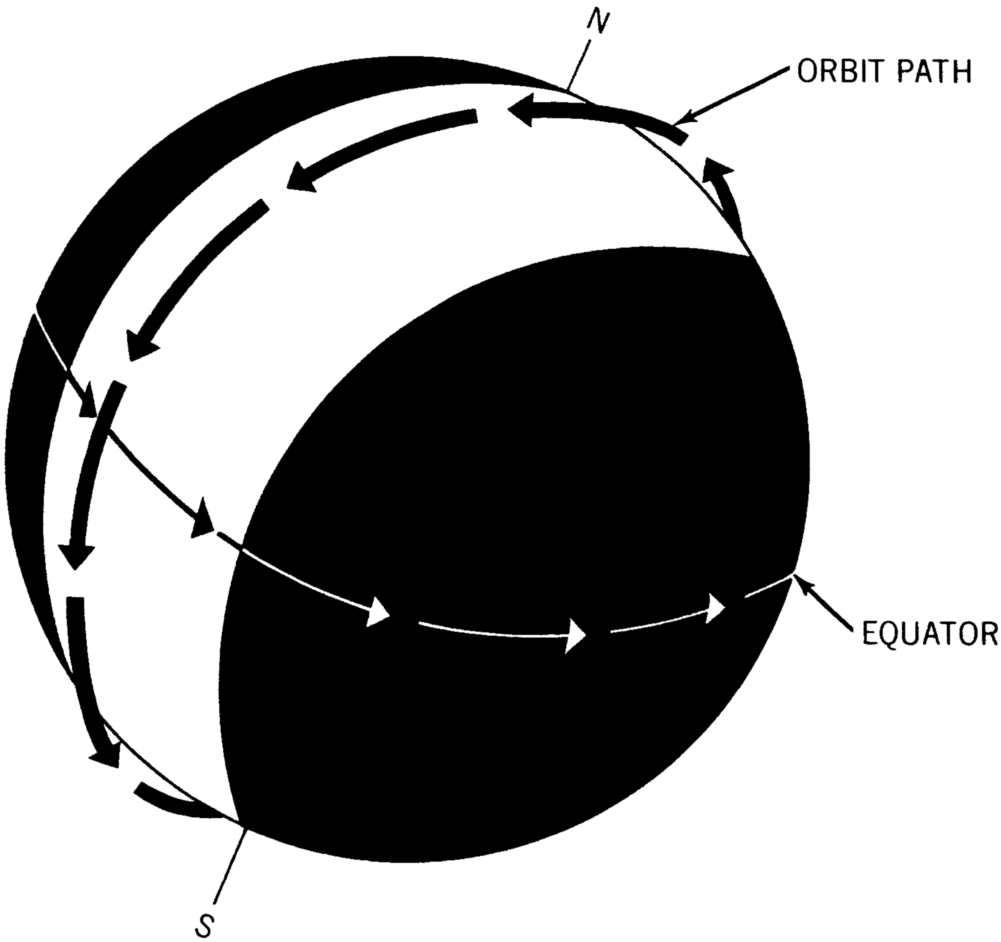
Nimbus C takes pictures in total darkness, by the use of infrared rays.

Conventional, daytime cloud photography, like the human eye, relies on sunlight scattered back into space by clouds, or the earth.

The human eye cannot see infrared just as the human ear cannot hear the high frequency sound of a dog trainer's whistle.

The 12-pound High Resolution Infrared Radiometer (HRIR) in Nimbus C is based on the principle that all surfaces on Earth emit infrared radiation according to their temperature (even ice); hot surfaces radiate more intensely than cold surfaces.

Infrared works as follows: Nimbus C's HRIR senses radiation with a lead selenide photo electric cell which operates at the low temperature of minus-135 degrees Fahrenheit.



HIGH-RESOLUTION INFRARED RADIOMETER (HRIR) COVERAGE

An approximately 1,500 mile wide strip extending halfway around the globe (12,500 miles) on the night side of each orbit is scanned by a continuously rotating mirror which focuses the radiation on to the photocell.

The mirror sweeps across this strip about 75 times every 100 seconds, thus covering the entire length of the strip with about 2,300 continuous scans.

Nimbus' photo electric cell converts the radiation stimulus into electrical signals which are stored on magnetic tape aboard the spacecraft.

When the playback command is given to the satellite from the ground, the signals are transmitted to the receiving station where pictorial images are produced on 70mm-film by a photo-facsimile device.

On each infrared picture, warm bodies of water such as the world's seas and oceans appear very dark; land which is cooler at night than the oceans, appears somewhat lighter; and clouds which are generally much colder than water, or land surfaces, vary from light grey to brillant white.

Since colder temperatures are usually found at higher altitudes, cloud brightness increases with altitude.

Meteorologists, by studying infrared pictures, can estimate the approximate height of cloud altitudes within 1,000 feet, and estimate the temperature of land and water surfaces within two degrees Fahrenheit.

The Nimbus HRIR, which has a resolution of five miles at picture center, operates at wavelengths of 3.4 to 4.2 microns in the infrared spectrum.

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Infrared experiments aboard the Nimbus I (HRIR) proved that the atmosphere is quite transparent in the spectral range of 3.4 to 4.2 microns. If clouds are absent, radiation emitted by the earth's land or water surfaces reaches the satellite with only minor interference by the clear atmosphere.

The ability of the HRIR in Nimbus I to map sea surface temperatures, with an accuracy of two degrees Fahrenheit, suggests that the course of various ocean currents, such as the Gulf Stream, can be detected by Nimbus.

Moisture content of the soil was also evident in Nimbus I infrared pictures. Many rivers of a width less than a few hundred yards stood out prominently in radiation pictures, although the linear resolution of the HRIR is generally not better than five miles.

The prominence of rivers is apparently due to the fact that the heat capacity of the ground along a river is altered, probably by moisture in the ground, and this moisture retains solar heat absorbed during daytime much longer than the adjacent river.

Despite their prominence in infrared pictures, several rivers, except for occasional spring flooding, carried practically no water.

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Also, these rivers did not form any deep canyons or other depressions, so their warmer temperatures cannot be explained by height differences.

Over a period of time the courses of some rivers have meandered over widths of several miles over the desert plateau.

These meanderings have apparently taken place during floods, and have altered the terrain to such an extent as to create a sufficient contrast in the thermal properties between the desert and the river beds that the nighttime temperature differences could be detected by the radiometer in Nimbus I.

A thorough analysis of the infrared pictures returned by Nimbus I has produced a variety of new geophysical and atmospheric facts regarding temperature variations over the earth's terrain.

Over heavily vegetated regions of the tropics the ground temperature can be measured, and, because of the larger heat capacity of this type of terrain, its effect on air temperatures is similar to that over oceans.

Also, the ground acts as a reservoir which heats or cools the air moving over it depending on its temperature.

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At higher altitudes, especially over dry sandy terrain, the heat capacity of the ground is so small that near midnight, when solar radiation is absent, the ground temperature measured by Nimbus I is much less than the air temperature, indicating temperature inversions.

Over more solid rock surfaces the satellite-measured ground temperatures are more nearly equal to the air temperatures.

Contrasts in the thermal properties of the surfaces usually exhibit a very pronounced fine structure in the satellite observations.

In many cases these contrasts can be interpreted as a measure of moisture content of the ground, changes in the vegetation, or in the geological formation along the ground.

Medium Resolution Infrared Radiometer

One of the biggest jobs assigned to Nimbus C is to measure, for the first time on a global basis, the heat balance of the entire 200-million-square-mile-area of the Earth every day -- how much of the sun's radiation the world absorbs daily and how much is reflected back into the atmosphere.

Physicists at Goddard hope that this heat balance study may unlock some of the mystery of weather storm development and dissipation.

The 36-pound Medium Resolution Infrared Radiometer (MRIR), a five channel radiometer will measure the following:

. Water-vapor absorption--this band, at 6.5 to 7.0 microns (a micron is one millionth of a meter), provides information on atmospheric structure and water-vapor distribution. The energy observed in this channel reflects the temperature profile and relative humidity of the atmosphere.

. Atmospheric window--measure the temperature of the earth in the 10-to-11-micron band where the atmosphere is transparent. These measurements provide information on the Earth's surface temperature and lower atmosphere radiation. In addition, maps showing isolines (equal lines) of radiant emittance can be interpreted as cloud cover maps, offering a backup to TV and HRIR pictures.

. Stratospheric temperatures--this band, at 14 to 16 microns, provides a measurement of the stratospheric (the upper portion of the atmosphere, above 35,000 feet, in which temperature changes little with altitude and clouds of water never form) temperatures by measuring the emission from the carbon dioxide absorption band.

. Terrestrial radiation--covers the range of thermal emissions from the earth (7 to 30 microns), permitting a study of the energy budget of the earth through measurements of the earth's total longwave infrared emission.

. Albedo radiation--provides measurements of energy levels in the visible and near infrared (0.2 and 4 micron) range to determine the amount of solar energy reflected by the Earth and its atmosphere (albedo of the Earth).

The MRIR sensor employes a scanning motor optic system with detectors at the focal point and mechanical light beam choppers, and provides a resolution of about 30 miles from an orbital altitude of 690 miles.

Each detector produces a signal reflecting the radiation intensity within the spectral band to which it is sensitive.

The voltages representing meteorological and experimental data are sampled in a formatted sequence, converted to digital form, stored on a digital tape recorder in the spacecraft, and upon command from the ground, transmitted to a data acquisition station in Alaska or North Carolina.

All MRIR data, like daytime television pictures and HRIR photos, are immediately microwaved to Goddard to be processed in near real time. The processing time, including gridding (latitude and longitude lines so engineers know precisely where the data were collected), of MRIR data is about 15 minutes.

Nimbus Ground Operations

The Nimbus C ground operations are divided into five general areas: Data Acquisition Facilities (DAF), at Fairbanks, Alaska, and Rosman, North Carolina; the Nimbus Technical Control Center (NTCC) at Goddard, the nerve center for all Nimbus operations; the Nimbus Data Handling System (NDHS) at Goddard, the system for receiving spacecraft performance data and pictures from the two data acquisitions facilities; the Nimbus Data Utilization Center (NDUC) at Goddard, the system for processing and distributing all meteorological data and pictures; and the Automatic Picture Transmission (APT) ground equipment which is required to receive daytime and nighttime pictures.

Nimbus Technical Control Center

The nerve center for all Nimbus activity is the Nimbus Technical Control Center (NTCC) at Goddard.

This center evaluates spacecraft performance and determines all of the commands to be sent to Nimbus C from the data acquisition facilities in Alaska and North Carolina.

The NTCC will be manned around the clock.

Functions of the NTCC are:

- Prepare all spacecraft command sequences;
- Perform continuing analysis of key spacecraft parameters;
- Determine corrective action in case of spacecraft subsystem malfunction;
- Specify the sequence of data processing;
- Evaluate system performance by studying the quality of the data received;
- Monitor and evaluate the Nimbus Data Handling System ground equipment starters and performance; and
- Schedule the Nimbus Data Utilization System to provide meteorological data to the National Weather Satellite Center, Suitland, Md.

Data Acquisition Facilities

All spacecraft and meteorological data from Nimbus are received by two large 85-foot-diameter parabolic antennas at Fairbanks, Alaska, and Rosman, North Carolina.

All of the Nimbus data received at the two DAFs are immediately microwaved to Goddard for processing and analysis.

The antennas at both sites are identical. The surface of the large electronic "ears" consists of double-curved aluminum sheet panels which are separated from the reflector structure to permit independent adjustment.

The antennas have a gain of approximately 50 decibels at 1,700 megacycles, with a beamwidth of 0.7 degrees. At 136 megacycles, the antennas have a gain of approximately 26 decibels with a 6-degree beamwidth.

Mounted on an X-Y mount, designed specifically for tracking satellites, the antenna reflectors can track Nimbus without requiring excessive shaft velocities from the antenna-drive system.

Antenna feeds have a monopulse autotrack capability on 136 and 1,700 megacycles, the two frequencies used by Nimbus C.

Fairbanks acquires the spacecraft on 10 of the 14 daily orbits and Rosman acquires two of the four passes missed by Fairbanks. Two orbits cannot be read out immediately, however data can be stored on the spacecraft for later readout.

Nimbus Data Handling System

The Nimbus Data Handling System (NDHS) collects and processes spacecraft performance data and meteorological sensory data.

Two computers monitor the spacecraft's performance and grid each picture.

To process all of the data coming in from Rosman and Fairbanks, the NDHS will run continually.

The sequence for sending meteorological data from Nimbus to the ground is as follows:

Immediately after the satellite has been acquired by Rosman or Fairbanks, the Nimbus S-band transmitter is turned on by ground command.

After 45 seconds of S-band warmup, the spacecraft begins sending daytime and nighttime pictures which have been stored on tape recorders in the satellite. As the data are received at Alaska and Rosman, they are immediately microwaved to the NDHS at Goddard.

HRIR and MRIR data are recorded on tape recorders at the NDHS, processed on-line, and recorded and gridded on 70mm filmstrip. Approximately 15 minutes is required for photographic processing before the infrared data are ready for review.

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While HRIR and MRIR data are being transmitted, the spacecraft is also sending video signals containing AVCS pictures. It takes approximately four minutes to send one orbit's supply, or 96 pictures.

Pictures taken by the AVCS are recorded on three channels on two tape recorders. The pictures are processed immediately on 70mm filmstrips.

The total time to receive both spacecraft performance data and weather pictures is 10 minutes after the tracking station first acquires the spacecraft.

Direct AVCS pictures taken when within range of a data acquisition facility can be processed and gridded on the ground only 60 seconds after the pictures are taken.

Nimbus Data Utilization Center (NDUC)

All film processing is done by the Nimbus Data Utilization Center (NDUC), which will index, catalog, store, and retrieve Nimbus C sensory data (AVCS, HRIR, MRIR and APT).

Because one of the prime experiments of Nimbus C is to process film in near real time for immediate distribution to meteorologists, the center will operate 24 hours a day.

The objectives for the NDUC are:

- Near real time handling of data accountability and quality control, interpretation, extraction and documentation of the data, and photographic processing and storage;
- Production of monthly users catalogs containing consolidated and selected information on AVCS, HRIR, MRIR, APT (daytime and nighttime) data. Catalogs will be published at 30-day intervals within 30 days of the end of each catalog period;
- Establish a cataloging, indexing, storage and retrieval and reproduction system for all Nimbus C meteorological data; and
- Retrieval and reproduction of Nimbus C data to satisfy experimenters and special requestors.

Automatic Picture Transmission Ground Equipment

Simplicity, economics, and live pictures make the Automatic Picture Transmission camera in Nimbus C extremely appealing to local weather men.

Some ham radio operators, who have much of the electronic equipment necessary to operate a ham station, have built APT stations for only a few hundred dollars.

A typical ground station consists of a manually tracked 13-decibel helix antenna which is about 12 feet long, a commercially available radio receiver, and a standard facsimile machine.

The 800 line APT picture and 0.25-sec. scanning time per line are compatible with standard 240-revolutions per minute facsimile equipment.

APT pictures are sent to the ground by a five-watt transmitter using the 136.95 megacycle frequency. This same frequency also sends the start and synchronization signals to alert the station that Nimbus is approaching.

One of the most interesting experiments planned for Nimbus C is the Direct Readout of Infrared (DRIR) on APT equipment.

NASA has sent manuals to all APT stations which instruct operators of the changes which are necessary to receive infrared pictures.

Basically, the modifications involve a gear change (daytime pictures in Nimbus are scanned out at 240 revolutions per minute while infrared photographs will be scanned out at 45 revolutions per minute) plus some minor electronic changes.

Another important experiment slated for the Nimbus C mission is a communications subsystem in the spacecraft designed to provide APT stations with daily orbital information which is necessary for receiving pictures.

Each APT picture, both daytime and nighttime, will have a code written on the left side of the picture which contains daily orbital information.

The APT operator, by using a manual furnished by NASA, can thus determine satellite arrival times and antenna pointing angles for each daily orbit.

Project officials hope that the data code experiment will eventually eliminate the need for sending orbital information to APT stations via teletype.

Direct Readout Infrared Stations

Goddard Space Flight Center
Greenbelt, Md.

Ulaska Data Acquisition Facility
Fairbanks, Alaska

Nimbus Project, RCA
Princeton, N.J.

National Weather Satellite Center
Suitland, Md.

USAF Geophysics Research Directorate
Hanscom Field, Mass.

WLAC-TV
Nashville, Tenn.

G. F. Andrews
Miami, Fla.

Weather Engineering Corp. of Canada, Ltd.
Dorval, Canada

Deutsche-Forschungsanstalt
Fur Luft Und Raumfahrt E.V. (DVL)
Braunschweig, Germany

University of Tennessee
Tullahoma

Northern State College
Aberdeen, S. Dak.

Goddard Transportable Ground Station
Mojave, Calif.

Navy Fleet Weather Central
Mariana Islands

WSM, Inc.
Nashville, Tenn.

Automatic Picture Transmission Ground Stations

NASA Stations

Nimbus Project, RCA
Princeton, N.J.

Wallops Station
Wallops Island, Va.

Marshall Space Flight Center
Huntsville, Ala.

Ulaska Data Acquisition Facility
Fairbanks, Alaska

General Electric Co.
Philadelphia, Pa.

Tananarive, Malagasy Republic

Fort Myers, Fla.

University of Alaska
College

Manned Spacecraft Center
Houston

Army Stations

Electronics Command
Fort Monmouth, N.J.

Electronics Command
White Sands, N.M.

Navy Stations

Naval Support Forces
Antarctica

Naval Support Forces
McMurdo Sound, Antarctica

Fleet Weather Central
Mariana Islands

Naval Missile Center
Pt. Mugu, Calif.

Naval Postgraduate School
Monterey, Calif.

Fleet Weather Central
FPO San Francisco

Fleet Weather Central
FPO New York

Naval Air Station
Jacksonville, Fla.

Washington Navy Yard
Washington, D.C.

Naval Air Station
Lakehurst, N.J.

Navy Electronics Laboratory
San Diego, Calif.

USS Constellation
FPO San Francisco

USS Oriskany (CVA 34)
FPO San Francisco

Project FAMOS
Washington, D.C.

Fleet Weather Facility
FPO San Francisco

Naval Station
FPO San Francisco

Fleet Weather Facility
FPO San Francisco

Fleet Weather Facility
FPO New York

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Air Force Stations

Geophysics Research Directorate
Hanscom Field, Mass.

Det. #1, 3rd Weather Wing
Offutt AFB, Neb.

Det. #1, 4th Weather Wing
Ent AFB, Colo.

Det. #2, 5th Weather Wing
Langley AFB, Va.

Det. #10, 8th Weather Squadron
Westover AFB, Mass.

Det. #30, 6th Weather Wing
Vandenberg AFB, Calif.

Det. #13, 11th Weather Squadron
APO Seattle

Det. #3, 1st Weather Wing
APO San Francisco

Det. #1, 20th Weather Squadron
APO San Francisco

Det. #5, 1st Weather Wing
APO San Francisco

Det. #8, 20th Weather Squadron
APO San Francisco

Det. #40, 28th Weather Squadron
APO New York

Det. #21, 31st Weather Squadron
APO New York

Det. #18, 15th Weather Squadron
APO New York

Det. #19, 15th Weather Squadron
APO New York

Tuslog Det. #2
APO New York

Det. #15, 20th Weather Squadron
APO San Francisco

30th Weather Squadron
APO San Francisco

Det. #17, 31st Weather Squadron
APO New York

Det. #11, 6th Weather Wing
Patrick AFB, Fla.

Air Training Command
Keesler AFB, Miss.

Det. #6, 4th Weather Wing
Peterson Field, Colo.

Liaison Officer, NESC
Washington, D.C.

ESSA Stations

Nat'l Environmental Satellite Ctr
Washington, D.C.

Weather Bureau Airport Station
East Boston, Mass.

Weather Bureau Airport Station
Jamaica, N.Y.

District Meteorological Office
Miami, Fla.

Weather Bureau Office
New Orleans

Weather Bureau Airport Station
Chicago

Weather Bureau Forecast Center
Chicago

Weather Bureau Airport Station
Jacksonville, Fla.

Weather Bureau Airport Station
San Antonio, Tex.

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Weather Bureau Airport Station
Seattle-Tacoma Airport, Wash.

Weather Bureau Airport Station
Anchorage

Weather Bureau Airport Station
Honolulu

Weather Bureau Airport Station
San Juan, P.R.

Weather Bureau Airport Station
Wake Island

Weather Bureau Airport Station
Topeka, Kans.

Weather Bureau Forecast Center
Kansas City, Mo.

Weather Bureau Airport Station
San Francisco

Weather Bureau Airport Station
Great Falls, Mont.

Weather Bureau Airport Station
Salt Lake City

Weather Bureau Airport Station
Albuquerque

International Stations

Meteorological Service of Canada
Toronto

Meteorological Service of Canada
Ottawa

Meteorological Service of Canada
Montreal

Meteorological Service of Canada
Halifax

Meteorological Service of Canada
Frobisher

-more-

Meteorological Office
Bracknell, Berkshire, U.K.

Meteorological Office
London Airport

Meteorological Office
Aden, U.K.

Meteorological Office
Cyprus

Meteorological Office
Doha, Qatar, U.K.

Meteorological Office
Singapore

Meteorological Office
Maldive Islands, U.K.

Royal Observatory
Hong Kong

Meteorological Office
San Jose, Costa Rica

Det Norske Meteorologiske Instituut
Oslo, Norway

Det Danske Meterologisk Institut
Copenhagen

Royal Netherlands Meteorological Institute
De Bilt, Netherlands

La Meteorologie Nationale
Paris

Centre D'Etudes Meteorologigues Spatiales
Lannion, France

Bundes Ministerium der Verteidigung
Bonn

Deutscher Wetterdienst
Offenbach, Germany

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Institut Swisse de Meterologie
Zurich

Institut Swisse de Meterologie
Geneva

Meteorological Department
Cairo

East African Common Services Org.
Nairobi, Kenya

Service Meteorologique
Tananarive, Malagasy Republic

Colaba Observatory
Bombay

Pakistan Space and Upper Atmos. Res. Comm.
Dacca, Pakistan

Japan Meteorological Agency
Tokyo

Philippine Weather Bureau
Manila

Commonwealth Bureau of Meteorology
Melbourne

Commonwealth Bureau of Meteorology
Darwin, Australia

Commonwealth Bureau of Meteorology
Perth, Australia

New Zealand Meteorological Service
Wellington, New Zealand

Met Office
Nandi, Fiji Islands

Chief of Meteorological Service
Papeete, Tahiti

Private Users, U.S.

Scientific Atlanta Inc.
Atlanta, Ga.

George F. Andrews
Miami, Fla.

Ray Leep
Tampa, Fla.

Boeing Co.
Huntsville, Ala.

WLAC - TV
Nashville, Tenn.

WSM - Inc.
Nashville, Tenn.

University of Tennessee
Tullahoma, Tenn.

Western Kentucky State College
Bowling Green, Ky.

John F. Kline
Royal Oak, Mich.

University of Michigan
Ann Arbor

Dr. E. Epstein
Ann Arbor

Bendix Corp.
Ann Arbor

University of Wisconsin
Madison

South Dakota Sch. of Mines & Tech.
Rapid City

St. Louis University
St. Louis

Larry Plummer
Wichita, Kans.

L. G. Riddle
New Orleans

Midwest Instrument Co.
Tulsa

KPRC - TV
Houston

KZTV Channel 10
Corpus Christi, Tex.

California Computer Products
Anaheim, Calif.

Boeing Scientific Res. Labs.
Seattle

Northern State College
Aberdeen, S.D.

Northeast Weather Service
Bedford, Mass.

University of California
Los Angeles

E. H. Phinney
Richland, Wash.

Private Users, Foreign

RCA Victor Co., Inc.
Montreal

Weather Engineering Corp. of Canada, Ltd.
Dorval, Canada

David Sloan
Vancouver, Canada

Comissao Nacional de Atividades Espaciais
S. Jose Dos Campos, Brazil

Universidad Nacional de Tucuman
San Miguel de Tucuman, Argentina

University of Chile
Santiago, Chile

Deutsche-Forschungsanstalt fur Luft und Raumfahrt E.V. (DFL)
Branschweig, Germany

Sternwarte der Stadt Bochum
Bochum, Germany

Rohde & Schwarz
Munchen, Germany

Free University of Berlin
Berlin

Tel-Aviv University
Tel-Aviv

Kuala Lumpur Tech College
Malaysia

Radio and Microwave Laboratory
Bandung, Indonesia

Meteorological Research Institute
Tokyo

Weapons Research Establishment
Salisbury, South Australia

Department of Scientific & Industrial Research
Lower Hutt, New Zealand

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Launch Vehicles

The Thrust Augmented Thor Agena B is a launch vehicle developed by the U.S. Air Force which has been used for several NASA space launchings.

The Thrust Augmented Thor Agena B has the following general characteristics:

Height (includes shroud): 95 feet

Maximum Diameter: 8 feet (without attached solids)

Liftoff Weight: about 75 tons

Liftoff Thrust: 333,550 pounds, (including strap-on solids)

First Stage (liquid only): Modified Air Force Thor.

Diameter: 8 feet

Height: 51 feet

Propellants: RP-1 kerosene fuel and liquid oxygen (LOX).

Thrust: 172,000 pounds

Burning Time: 2 min. 38 sec.

Weight: Approximately 53 tons

Guidance: Inertial for the first 90 seconds (auto pilot), then radio command guidance.

<u>Strap-on Solids</u>: Three solid propellant Sergeant rockets produced by the Thiokol Chemical Corp.

Diameter: 31 inches

Height: 19.8 feet

Weight: 27,510 pounds (9,170 each)

Thrust: 161,550 pounds (53,850 each)

Burning Time: 43 seconds

<u>Agena B</u>:

Diameter: 5 feet

Height: 20 feet

Propellants: Liquid -- Unsymmetrical Dimethyl Hydrazine (UDMH) fuel and Inhibited Red Fuming Nitric Acid (IRFNA) oxidizer.

Thrust: 16,000 pounds

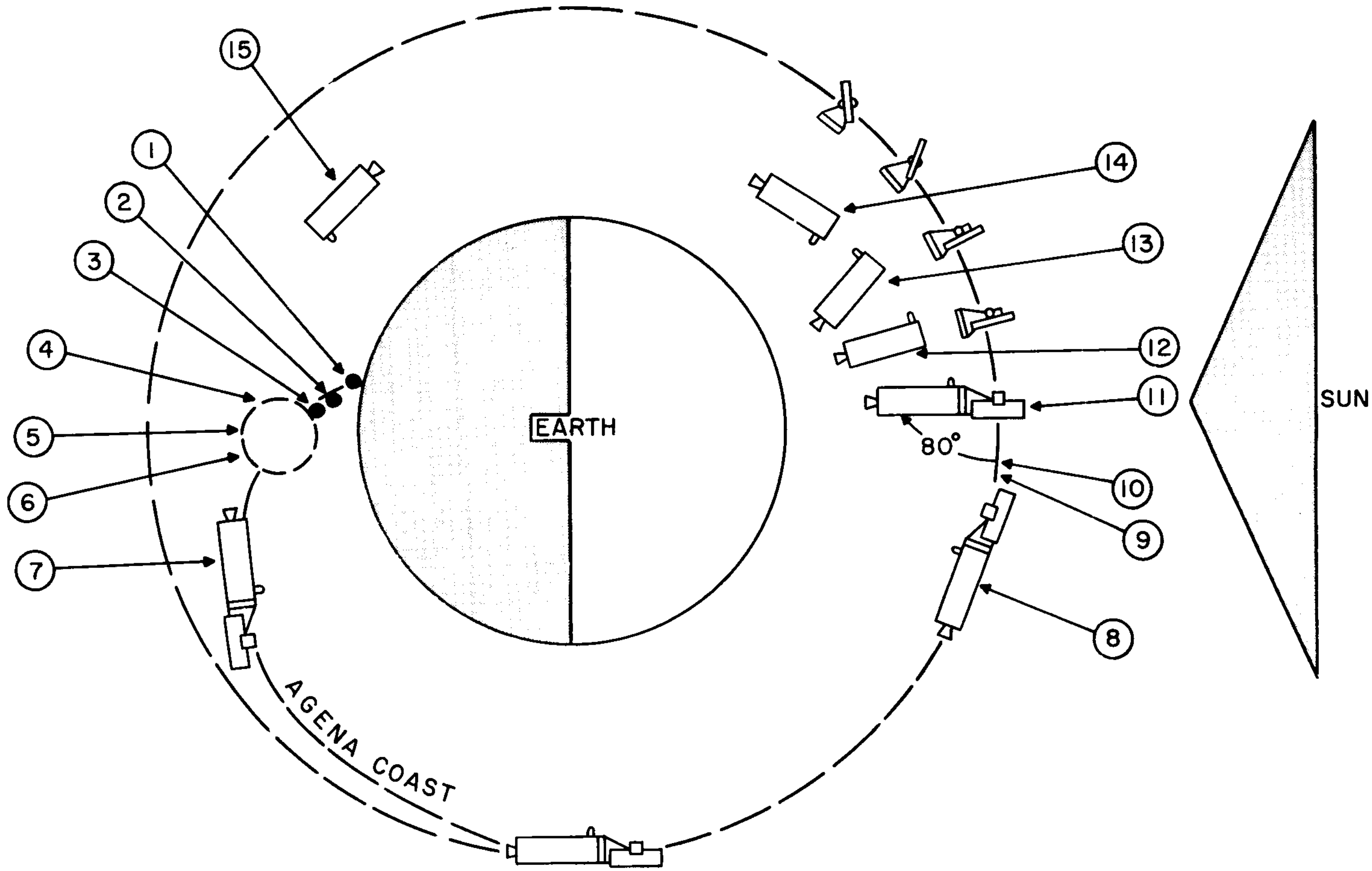
Burning Time: First burn 3 min., 53 sec.; Second burn 5 seconds.

Weight: 16,532 pounds

Guidance: Inertial

<u>The Flight Plan</u>: To achieve a near polar, Sun-synchronous orbit the Agena has been programmed for a two-burn mission. Orbital injection is scheduled southeast of Tananarive, Malagasy Republic, some 12,500 miles from launch point.

THOR AGENA B FLIGHT EVENTS FOR NIMBUS C MISSION



1. LAUNCH FROM VAFB.
2. TAT MAIN ENGINE CUTOFF (MECO).
3. TAT VERNIER CUTOFF (VECO)
4. TAT/AGENA SEPARATION.
5. AGENA FIRST BURN.
6. NOSE SHROUD SEPARATION.
7. AGENA FIRST CUTOFF.
8. AGENA SECOND IGNITION.
9. AGENA SECOND CUTOFF.
10. INITIATE 60°/MINUTE PITCHUP.
11. TERMINATE PITCHUP.
12. SEPARATE SPACECRAFT.
13. INITIATE YAW/ROLL MANEUVER.
14. TERMINATE YAW/ROLL MANEUVER, FIRST RETRO.
15. SECOND RETRO.

The nominal orbital elements include an apogee and perigee of 690 statute miles, an orbital period of 107 minutes, and an inclination angle to the equator of 80 degrees (retrograde).

The Thrust Augmented Thor Agena B will rise straight up from Space Complex 1-1 at the Western Test Range for 10 seconds, then roll to its azimuth of 194 degrees true and be steered by an autopilot until 90 seconds after liftoff; then the ground-based guidance system takes over.

At approximately 150 seconds after liftoff, Thor's main engine shuts off and the vehicle continues its flight powered by the vernier engines which position the vehicle in response to signals from the ground.

The vernier engines cut off at about 159 seconds after ignition and the two-stage vehicle coasts upward for 28 seconds awaiting Agena B ignition for the first time.

During this short coast period, Agena's inertial guidance system will command the vehicle to pitch down and be nearly parallel to the curvature of the Earth.

Agena B ignites at 194 seconds after liftoff and 10 seconds later a programmed signal jettisons the protective shroud which covers the spacecraft, ejecting it away from Agena and Nimbus C.

The shroud, standing 19 feet high and resembling a giant clam shell, protects Nimbus from the scorching heat of the high velocity through the atmosphere during the early portion of powered flight. It is no longer needed in the vacuum conditions of space.

At seven minutes and seven seconds into the flight, Agena shuts down for the first time and the vehicle, with spacecraft, will coast for 45 minutes from 98 miles high to 690 miles.

When this altitude is reached, Agena will fire again, a short five-second burst which will kick the spacecraft into a circular orbit 690 statute miles above the Earth.

Spacecraft Separation Procedure

Following insertion into orbit, Agena B and Nimbus are stabilized in all three axes (pitch, yaw and roll) by Agena's inertial control system. The Agena horizon scanners are then turned off, and an 80-degree pitch-up maneuver is executed at a rate of one degree per second.

Explosive boltcutters on the V-band separation clamp securing the spacecraft to the adapter are ignited 112 seconds after the second Agena burnout and Nimbus C and Agena B separate.

Calibrated separation springs provide a separation velocity of four feet per second. The delay in separation eliminates the possibility of a thrust impulse arising from boiloff of residual propellants in Agena B.

Nimbus is now pointing at an 80-degree angle toward the earth, still 10 degrees from being earth oriented. The final 10-degree correction is made by the gas jets in the satellite's control system and electrically-driven flywheels.

Sun-Synchronous Orbit

To achieve a Sun-synchronous high noon orbit, Nimbus C must be launched at a certain time of the day. The launch window opens at 12:54 A.M. PDT, and closes at 1:58 A.M.

A high noon orbit is ideal for weather satellites because it provides maximum power for the satellite's batteries, maximum illumination for photographic purposes, and pictures of the Earth will always be taken at the same local Sun time every day (about noon). Nighttime photos will be taken about midnight local time.

In a Sun-synchronous orbit, the precession (eastward drift) of Nimbus will be about one degree daily, at the same rate and direction as the Earth moves around the Sun. The Sun will always be behind Nimbus during daylight orbits, which results in ideal lighting conditions for taking pictures.

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Nimbus C Nominal Flight Events

Event	Time	Altitude (Statute Miles)	Surface Range (Statute Miles)	Velocity (Miles per hour)
Solid Burnout	43 sec.	6.6	3.6	1,192
Solid Separation	1 min. 5 sec.	12.6	9.8	1,741
Thor Main Engine Cutoff (MECO)	2 min. 30 sec.	49	103	8,318
Thor Vernier Engine Cutoff (VECO)	2 min. 39 sec.	54	123	8,308
Thor Separation	2 min. 47 sec.	59	142	8,255
Agena First Burn	3 min. 15 sec.	73	204	8,142
Shroud Separation	3 min. 25 sec.	76	223	8,352
Agena First Cutoff	7 min. 7 sec.	98	944	18,070
Agena Second Ignition	52 minutes	690	12,500	16,022
Agena Second Cutoff	52 min. 5 sec.	690	12,527	16,564
Spacecraft Separation	56 min. 24 sec.	690	13,738	16,564

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NIMBUS PROJECT OFFICALS

NASA HEADQUARTERS

Dr. Homer E. Newell	Associate Administrator for Space Science and Applications
Leonard Jaffe	Director, Space Applications Office
Dr. Morris Tepper	Deputy Director, Space Applications Office and Director of Meteorology
Dr. Richard Haley	Nimbus Program Manager
Vincent L. Johnson	Launch Vehicle and Propulsion Programs Director
Joseph B. Mahon	Agena Program Manager

GODDARD SPACE FLIGHT CENTER

Dr. John F. Clark	Acting Director
Dr. John W. Townsend, Jr.	Deputy Director
Robert E. Bourdeau	Assistant Director for Projects
Harry Press	Nimbus Project Manager

LEWIS RESEARCH CENTER

Dr. Seymour C. Himmel	Assistant Director of Launch Vehicles
H. Warren Plohr	Agena Project Manager

KENNEDY SPACE CENTER

Robert H. Gray	Assistant Director for Unmanned Launch Operations
Joseph B. Schwartz	Manager, Unmanned Launch Operations, Western Test Range, Operations Div.

U.S. AIR FORCE

Colonel Roy W. Worthington	Test Director, Deputy for Ballistic and 6595 Aerospace Test Wing, Vandenberg Air Force Base

GENERAL ELECTRIC COMPANY

E. S. Pelling	Nimbus C Program Manager Spacecraft Department Valley Forge, Pennsylvania

RADIO CORPORATION OF AMERICA

Irving Brown	RCA Project Manager Astro Electronics Division Princeton, New Jersey

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Major Spacecraft Subsystem Contractors

Company	Subsystem
Aracon Geophysics Division Allied Research Associates, Inc. Concord, Mass.	Data Code Experiment
California Computer Products Los Angeles	Command clock, Medium Resolution Infrared Radiometer electronics
General Electric Company Spacecraft Department Valley Forge, Pa.	Nimbus integration and test, stabilization and control subsystem, spacecraft structure and antennas
General Electronics Laboratories Cambridge, Mass.	S-band transmitter
Hughes Aircraft Co. Culver City, Calif.	PCM (telemetry) transmitter
International Telephone & Telegraph Industrial Laboratories Ft. Wayne, Ind.	High Resolution Infrared Radiometer
Lockheed Electronics Co. Industrial Technology Division Edison, N.J.	Medium Resolution Infrared Radiometer Tape Recorder
Radiation, Inc. Melbourne, Fla.	PCM telemetry
Radio Corporation of America Astro Electronics Division Princeton, N.J.	Advanced vidicon camera subsystem and tape recorder, Automatic Picture Transmission camera, HRIR tape recorder, command receivers, solar paddles and power supply subsystem, and the direct readout infrared subsystem
Raymond Engineering Middletown, Conn.	PCM (telemetry) tape recorder
Santa Barbara Research Center Subsidiary of Hughes Aircraft Co. Santa Barbara, Calif.	Medium Resolution Infrared Radiometer

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Launch Vehicle Contractors

Company	Responsibility
Bell Aerosystems Co. Buffalo, New York	Agena B engine
Douglas Aircraft Co. Missiles and Space Systems Division Santa Monica, California	Thor Booster
Electrosolids Los Angeles	Thor autopilot
Minneapolis-Honeywell Minneapolis	Thor autopilot
Texas Instruments Dallas	Thor autopilot
Lockheed Missiles and Space Co. Division of Lockheed Aircraft Co. Sunnyvale, California	Agena B vehicle (airframe and associated electronics)
Rocketdyne Division of North American Aviation, Inc. Canoga Park, California	Thor engine
Thiokol Chemical Corporation Huntsville, Alabama	Solid propellant strap-on boosters
Western Electric Company Burlington, North Carolina	Thor guidance system

Major Ground Equipment Contractors

Company	Responsibility
Adler/Westrex Communications Division of Litton Systems, Inc. New Rochelle, New York	HRIR Facsimile Equipment
Aracon Geophysics Division Allied Research Associated, Inc. Concord, Mass.	Operate the Nimbus Data Utilization Center
California Computer Products Los Angeles	Ground Station (NDHS) Command Console
Collins Radio Company Dallas	85-Antenna Ground Electronics
Control Data Corporation Minneapolis	Ground Station (NDHS) Computers
Electronic Image Systems Corp. Boston	MRIR Film Processing Equipment
General Electric Company Spacecraft Department Valley Forge, Pa.	Operate the Nimbus Technical Control Center
Photo Mechanisms, Inc. Huntington Station, N.Y.	Rapid Film Processing System for Advanced Vidicon Camera Pictures
Radiation, Inc. Melbourne, Fla.	PCM Telemetry Equipment
Radio Corporation of America Astro Electronics Division Princeton, N.J.	Operate the Nimbus Data Handling System (NDHS), Advanced Vidicon Camera Equipment, and the HRIR Signal Processing System
Rohr Corporation Chula Vista, Calif.	85-foot Antennas
Telemetrix Inc. Division of Technical Measurements Inc. Santa Ana, Calif.	Computer System for Processing MRIR Data

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